FIGARO

an ISO9001 company

Technical Information for Carbon Monoxide Sensors

The Figaro TGS3870-F04 sensor is a small bead-type metal oxide semiconductor. The sensor's miniature size and cyclic heater operation enable its single sensing element to be highly selective to carbon monoxide and to show low power consumption.

See also Technical Brochure "Technical Information on Usage of TGS Gas Sensors for Explosive/Toxic Gas Alarming".

<u>IMPORTANT NOTE</u>: OPERATING CONDITIONS IN WHICH FIGARO SENSORS ARE USED WILL VARY WITH EACH CUSTOMER'S SPECIFIC APPLICATIONS. FIGARO STRONGLY RECOMMENDS CONSULTING OUR TECHNICAL STAFF BEFORE DEPLOYING FIGARO SENSORS IN YOUR APPLICATION AND, IN PARTICULAR, WHEN CUSTOMER'S TARGET GASES ARE NOT LISTED HEREIN. FIGARO CANNOT ASSUME ANY RESPONSIBILITY FOR ANY USE OF ITS SENSORS IN A PRODUCT OR APPLICATION FOR WHICH SENSOR HAS NOT BEEN SPECIFICALLY TESTED BY FIGARO.

TGS3870 is a UL recognized component in accordance with the requirements of UL2075. *Please note that component recognition testing has confirmed long term stability in 60ppm of methane and 15ppm of carbon monoxide; other characteristics shown in this brochure have not been confirmed by UL as part of component recognition.*

1. Specifications

1-1 *Features*

* Miniature size and low power consumption
* High sensitivity and selectivity to carbon monoxide (CO)
* Low sensitivity to alcohol vapor
* Long life and low cost

1-2 *Applications*

* Carbon monoxide detectors

1-3 *Structure*

Figure 1 shows the structure of TGS3870-F04. A heater coil and an electrode are embedded in a small bead of SnO_2 sensing material. The heater is connected to pin Nos. 1 and 3 while the electrode is connected to pin No. 2. Both the heater and the electrode are composed of Pt wire and are spot welded to sensor pins (made of Ni-Fe 42% alloy).

The sensor base is made of PBT (polybutylene terephthalate), and the sensor cap is made of stainless steel. The upper opening in the cap is covered with a double layer of 100-mesh stainless steel gauze (SUS316) and the sensor cap also has a silica gel/ activated charcoal filter for reducing the influence of interference gases.

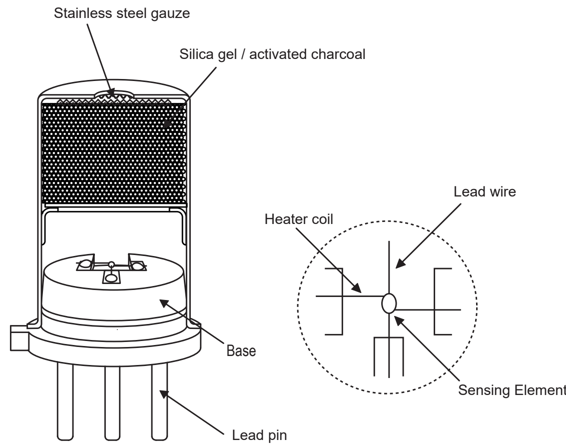

Figure 1 - Sensor structure

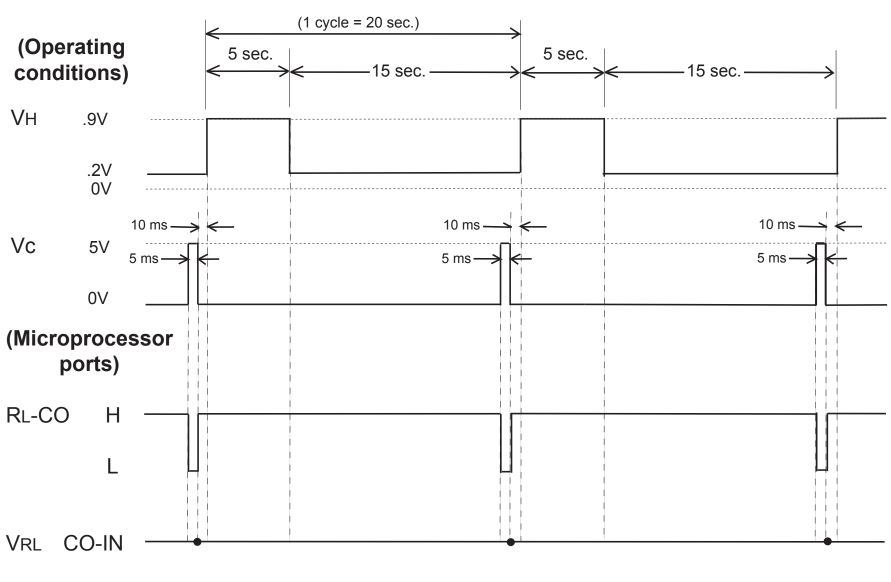

Figure 2 - Timing chart

1-4 *Specifications*

Model number			TGS3870-F04	
Sensing principle			MOS type	
Standard package			Plastic base and metal can	
Target gases			Carbon Monoxide	
Typical detection range			Carbon monoxide 50~1,000ppm	
Standard circuit conditions	Heater voltage	V_H	V_{HH} = 0.9V±3% for 5 sec. V_{HL} = 0.2V±3% for 15sec.	
	Circuit voltage	V_C	5.0±0.2V DC pulse	
	Load resistance	R_L	variable (>0.75kΩ)	
Electrical characteristics under standard test conditions	Heater resistance	R_H	3Ω±0.3Ω at room temp.	
	Heater power consumption	P_H	120mW	V_{HH} = 0.9V DC
			11mW	V_{HL} = 0.2V DC
			38mW	average
	Sensor resistance	R_S	2kΩ~40kΩ in 200ppm CO	
	Sensitivity (change ratio of Rs)	β	0.3~0.8	$\frac{Rs\ (300ppm\ CO)}{Rs\ (200ppm\ CO)}$
Standard test conditions	Test gas conditions		Target gas in air at 20±2°C, 65±5%RH	
	Circuit conditions		V_{HH} = 0.9V±2% for 5 sec. V_{HL} = 0.2V±2% for 15 sec. Vc = 5.0±0.02V DC pulse	
	Conditioning period before test		≥5 days	

NOTE: *Caution should be exercised in the selection of the load resistor (R_L) to ensure that power consumption (P_s) does **not** exceed 15mW.*

$$P_s = (V_{RS})^2/R_s$$

Ps reaches max. value when: $R_L = R_s$

Sensor resistance (Rs) is calculated with a measured value of V_{RS} by using the following formula:

$$R_s = \frac{(V_{RS} - 0.5V_H)}{(V_c - V_{RS})} \times R_L$$

Mechanical Strength:

The sensor shall have no abnormal findings in its structure and shall satisfy the above electrical specifications after the following performance tests:

Withdrawal Force (pin from base) - withstand force of 5kg in each direction

Vibration - vertical amplitude=1.5mm, frequency=10~500Hz, duration= 3 hours, direction=x,y,z (all)

Shock - acceleration-100G, repeat 5 times

1-5 *Dimensions*

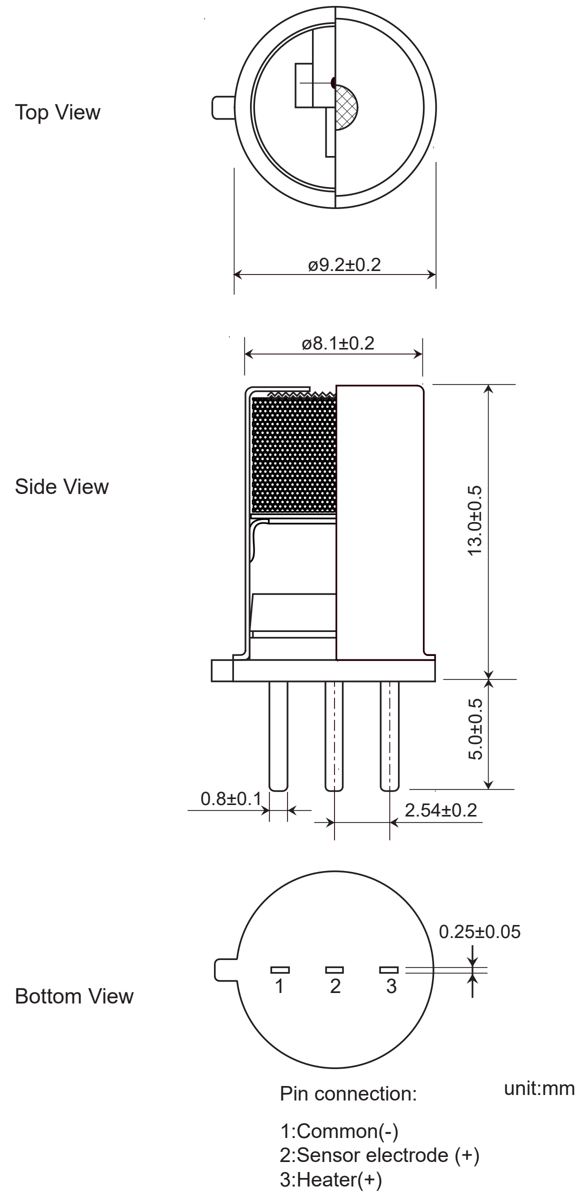

Figure 3 - Dimensions

All sensor characteristics shown in this brochure represent typical characteristics. Actual characteristics vary from sensor to sensor and from production lot to production lot. The only characteristics warranted are those shown in the Specification table above.

1-6 *Standard test conditions*

Standard test conditions for all data shown in this brochure were as follows:

Preheating of sensor: 5 days
VH (H/L): 0.9V/0.2V (see timing chart, Fig. 2)
VC: 5.0V pulse (see timing chart, Fig. 2)

1-7 *Basic measuring circuit*

The sensor requires two voltage inputs: heater voltage (VH) and circuit voltage (VC). The sensor has three pins: Pin #3--heater (+), Pin #2--sensor electrode (+), and Pin #1--common (-). To maintain the sensing element at specific temperatures which are optimal for sensing two different gases, heater voltages of 0.9V and 0.2V are alternately applied between pins #1 and #3 during a 20 second heating cycle (*see Fig. 2*).

Circuit voltage (VC) is applied between both ends of the sensor (Rs) and a load resistor (RL), which are connected in series, to allow measurement of voltage (VRS) as shown in Figure 4.

Circuit voltage (Vc) should be applied only at the moment when the signal is taken from the sensor (*please refer to Fig. 2*):

*for CO--5.0V for 5 msec. following VH of 0.2V for 14.985 sec.

Caution: Do not apply a constant circuit voltage (5.0V) or the sensor would not exhibit its specified characteristics.

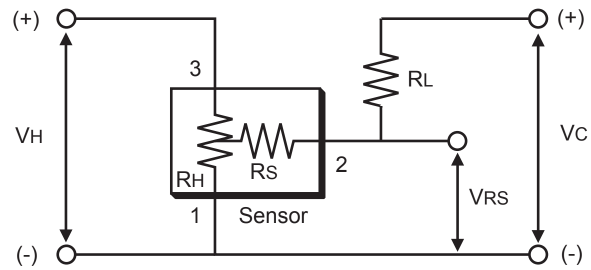

Figure 4 - Basic measuring circuit

2. Basic Sensitivity Characteristics

2-1 *Sensitivity to various gases*

Figure 5 shows the sensor's relative sensitivity to various gases. The Y-axis shows the ratio of sensor resistance in various gases (Rs) to the sensor resistance in 150ppm of CO.

Excellent sensitivity to CO is shown as evidenced by the sharp drop in sensor resistance as CO concentration increases. Selectivity is also quite good. In comparison to CO, sensitivity to hydrogen is very low as indicated by the extremely high concentrations of hydrogen required to approximate very low CO levels. Cross-sensitivity to methane is very low according to its high resistance values.

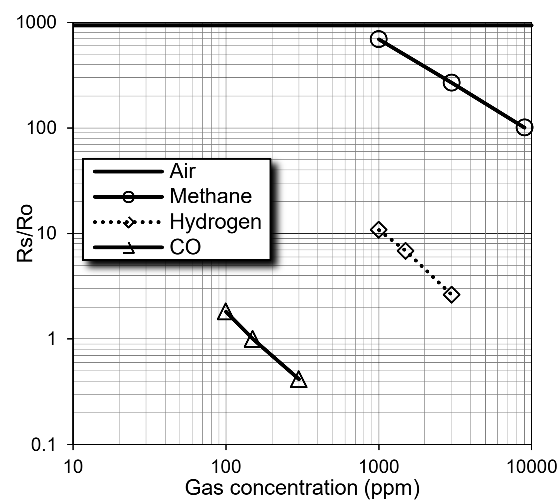

Figure 5 - Sensitivity to various gases for CO sensing
(Ro = Rs in 150ppm of CO, VH =0.2)

2-2 *Temperature dependency*

Figure 6 shows the temperature dependency of TGS3870-F04. The Y-axis shows the ratio of sensor resistance for gas concentrations under various atmospheric conditions (Rs) to the sensor resistance at 20˚C and 65%RH (Ro) for 150ppm of CO.

An inexpensive way to compensate for temperature dependency would be to incorporate a thermistor in the detection circuit. Separate compensation circuits should be prepared for CO sensing.

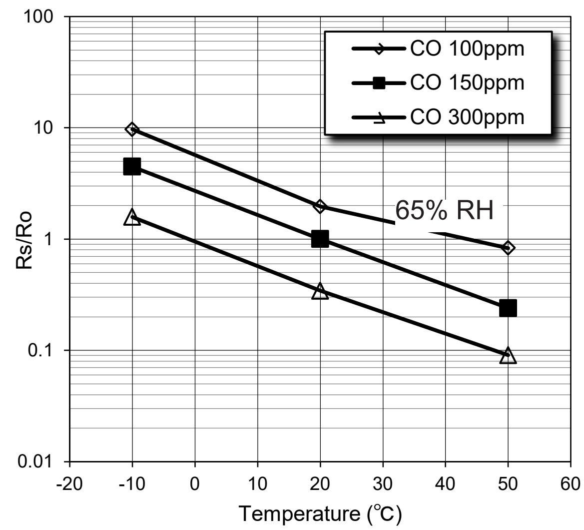

Figure 6 - Temperature dependency for CO sensing
(Ro = Rs in 150ppm of CO at 20˚C/65%RH, VH =0.2)

2-3 *Gas response*

Figure 7 shows the change patterns of sensor resistance (Rs) when the sensor is inserted into and later removed from 150ppm of carbon monoxide. Measurements were taken every 20 seconds.

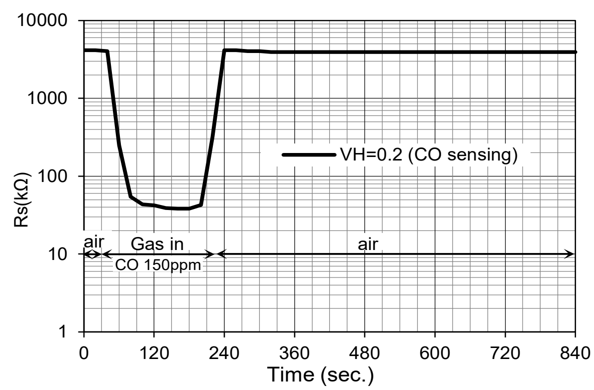

Figure 7 - Gas response speed - CO

2-4 *Long-term stability*

Figure 8 shows long-term stability data for TGS3870-F04. Test samples were energized in normal air and under standard circuit conditions (*see p.4*). Measurement for confirming sensor characteristics was conducted under standard test conditions (20˚C, 65%RH). The initial value was measured after two days of energizing in normal air at standard test conditions (*see p.4*). The Y-axis shows the ratio between measured sensor resistance and the initial (Day 0) resistance value in 150ppm of CO.

The characteristics for CO sensing are very stable for more than 350 days.

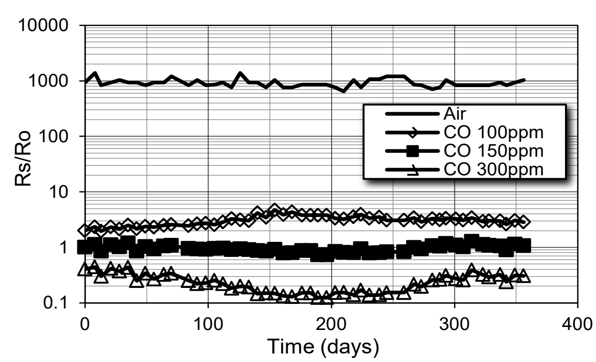

Figure 8 - Long term stability for CO sensing
(Ro = Rs in 150ppm of CO at Day=0, VH =0.2)

3. Cautions

3-1 *Situations which must be avoided*

1) Exposure to silicone vapors

If silicone vapors adsorb onto the sensor's surface, the sensing material will be coated, irreversibly inhibiting sensitivity. Avoid exposure where silicone adhesives, hair grooming materials, or silicone rubber/putty may be present.

2) Highly corrosive environment

High density exposure to corrosive materials such as H_2S, SO_x, Cl_2, HCl, etc. for extended periods may cause corrosion or breakage of the lead wires or heater material.

3) Contamination by alkaline metals

Sensor drift may occur when the sensor is contaminated by alkaline metals, especially salt water spray.

4) Contact with water

Sensor drift may occur due to soaking or splashing the sensor with water.

5) Freezing

If water freezes on the sensing surface, the sensing material would crack, altering characteristics.

6) Application of excessive voltage

If higher than specified voltage is applied to the sensor or the heater, lead wires and/or the heater may be damaged or sensor characteristics may drift, even if no physical damage or breakage occurs.

7) Operation in zero/low oxygen environment

TGS sensors require the presence of around 21% (ambient) oxygen in their operating environment in order to function properly and to exhibit characteristics described in Figaro's product literature. TGS sensors cannot properly operate in a zero or low oxygen content atmosphere.

8) Polarization

The sensor has polarity. An incorrect Vc connection may cause significant detrioration of long term stability. Connect Vc according to specifications.

9) Soldering

Sensors should be manually soldered--wave soldering is not recommended. The high heat generated during wave soldering may deform the resin parts and damage the sensor (e.g. the pressure-fitted sensor cap may separate from the base). For sensors with a filter cap (such as TGS3870-F04), deformation may create a gap between the sensor cap and base, alllowing interference gases to bypass the filter.

3-2 *Situations to be avoided whenever possible*

1) Water condensation

Light condensation under conditions of indoor usage should not pose a problem for sensor performance. However, if water condenses on the sensor's surface and remains for an extended period, sensor characteristics may drift.

2) Usage in high density of gas

Sensor performance may be affected if exposed to a high density of gas for a long period of time, regardless of the powering condition.

3) Storage for extended periods

When stored without powering for a long period, the sensor may show a reversible drift in resistance according to the environment in which it was stored. The sensor should be stored in a sealed bag containing clean air; do <u>not</u> use silica gel. *Note that as unpowered storage becomes longer, a longer preheating period is required to stabilize the sensor before usage.*

4) Long term exposure in adverse environment

Regardless of powering condition, if the sensor is exposed in extreme conditions such as very high humidity, extreme temperatures, or high contamination levels for a long period of time, sensor performance will be adversely affected.

5) Vibration

Excessive vibration may cause the sensor or lead wires to resonate and break. Usage of compressed air drivers/ultrasonic welders on assembly lines may generate such vibration, so please check this matter.

6) Shock

Breakage of lead wires may occur if the sensor is subjected to a strong shock.

Before purchasing this product, please read the Warranty Statements shown in our webpage by scanning this QR code.

https://www.figaro.co.jp/en/pdf/Limited_Warranty_en.pdf

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